DYKEMA

Dykema Gossett PLLC
300 Ottawa Avenue N.W.
Suite 700
Grand Rapids, MI 49503
WWW.DYKEMA.COM
Tel: (616) 776-7500
Fax: (616) 776-7573
John A. Ferroli
Direct Dial: 616-776-7542
Direct Fax: 855-260-7258
Email: JFerroli@dykema.com

February 14, 2018

Via Email (FRANKSR1@michigan.gov)

Robert Franks
Supervisor
Budget Tracking and Site Management Unit
Superfund Section
Remediation and Redevelopment Division
Michigan Department of Environmental Quality
P.O. Box 30473
Lansing, MI 48909-7973

Re: State Disposal Landfill/Plainfield Township Wells Superfund Site, Kent County, MI

Dear Mr. Franks:

We have reviewed MDEQ's February 6, 2018 comments ("2/6/18 Comments") to the Vertical Aquifer Sampling and Monitoring Well Installation Work Plan ("Plan") presented on January 17, 2018 by Waste Management of Michigan, Inc. ("WMMI") in response to MDEQ's December 21, 2017 notice letter regarding the subject Site ("Notice").

The 2/6/18 Comments and the cover email from Ms. Alfano erroneously and repeatedly refer to "Waste Management, Inc." Your Notice was directed to, and the Plan was submitted by, Waste Management of Michigan, Inc. and no other entity.

Given the positions taken by MDEQ in its 2/6/18 Comments, and in an effort to cooperate with MDEQ and expedite the process, WMMI encloses a Revised Plan. WMMI continues to object to the scope of work demanded by MDEQ and reserves all of its rights in that regard. In particular, MDEQ has not published cleanup criteria for PFAS compounds other than PFOA and PFOS yet it insists that WMMI have samples analyzed for numerous such unregulated compounds. WMMI also objects to MDEQ's failure to investigate (or to require the investigation of) more probable sources of PFAS in the study area, including the Northeast Gravel Site. We have repeatedly raised this issue with you and never received a meaningful explanation for MDEQ's inaction.

The Revised Plan is subject to change and to the objections and reservations of right expressed in this letter, my January 17, 2018 letter, and WMMI's verbal communications with MDEQ. Neither this letter, any other communication by WMMI regarding the Notice or Site, nor any document prepared or submitted by WMMI in response to the Notice (including, without limitation, the Revised Plan) should be construed as an admission of liability by WMMI or any of its affiliated entities regarding any matter whatsoever or a waiver by WMMI or any such affiliated entities of any rights, defenses, or claims, all of which are expressly reserved.

Please notify me and Mr. Forney when you have completed your review of this Plan.

Very truly yours,

DYKEMA GOSSETT PLLC

John A. Ferroli

Enclosure

cc: James Forney
Phil Mazor
David Kline
Judith Alfano
Darren Bowling

Vertical Aquifer Sampling and Monitoring Well Installation Work Plan

State Disposal Landfill

Plainfield Township, Michigan

WASTE MANAGEMENT

Prepared for
Waste Management of Michigan, Inc.

January 2018
Revised February 2018

Vertical Aquifer Sampling and Monitoring Well Installation Work Plan

Plainfield Township, Michigan

Prepared for
Waste Management of Michigan, Inc.

January 2018
Revised February 2018

2828 Kraft Ave, Suite 256
Grand Rapids, Michigan, 49512

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Section 1

Introduction

1.1 Purpose

This revised Vertical Aquifer Sampling and Monitoring Well Installation Work Plan (VAS MWIWP) is submitted pursuant to (a) the December 21, 2017 Michigan Department of Environmental Quality (MDEQ) notice letter sent to Waste Management of Michigan, Inc. (WMMI) providing WMMI with the opportunity to voluntarily perform response activities described in the scope of work document attached to the notice letter and (b) the MDEQ comments on the draft VAS MWIWP, received by WMMI on February 7, 2018.

The groundwater monitoring network in the unconsolidated aquifer downgradient from the State Disposal Landfill (SDLF) in Plainfield Township, Michigan, was installed by a series of investigators over a period from the late 1980s to the mid-1990s (Figure 1). This network of wells has long provided and continues to provide sufficient information to assess the nature and extent of the groundwater downgradient of the SDLF. This information was presented in the MDEQ-approved Remedial Investigation dated December 1995 and the MDEQ-approved Feasibility Study dated November 1997. The last 25 years of groundwater monitoring data from this network indicate that the response activities performed by WMMI have been successful in significantly reducing concentrations of hazardous substances in groundwater. Existing data from the network indicate that the groundwater impacts associated with the landfill are well defined and controlled. This evidence has been provided, on an annual basis since 2006, to the MDEQ.

While WMMI believes that the current groundwater monitoring well network is sufficient, in response to the MDEQ's notice letter WMMI has agreed to voluntarily extend the monitoring network along Grand River Drive and 5 Mile Road, as described in this plan.

1.2 Scope

A total of five vertical profile soil borings (VP-1 through VP-5) will be installed, as detailed in this work plan, by a licensed well driller. Three vertical profile soil borings will be installed along Grand River Drive, one will be installed east of MW-14R along 5-Mile Road, and one between MD-7D and PT-1. Vertical aquifer sampling (VAS) will be performed through temporary wells placed in each boring to provide a vertical groundwater profile at each location. VAS will also assist in determining the appropriate location and screened interval for each of the potential new groundwater monitoring wells and/or nested monitoring wells (MW-33 through MW-35) to be installed along Grand River Drive and/or 5-Mile Rd.

During VAS, groundwater samples from the temporary wells will be collected at 5-foot intervals throughout the entire thickness of the aquifer. Groundwater samples will be analyzed for volatile organic compounds (VOCs), per- and polyfluoroalkyl substances (PFAS), 1,4-dioxane, chromium VI, the MI 10-metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc – totals), dissolved potassium, dissolved magnesium, calcium, chloride, sulfate, total dissolved solids, pH, specific conductance, ammonia, dissolved sodium, and bicarbonate alkalinity. The results of the VAS will be evaluated along with the results from previous VAS activities (performed between 1988 and 2007) to determine the location and screened intervals for the potential new monitoring wells to be installed. A description of the field methods used to install the temporary VAS wells, collect groundwater samples, and install and develop the permanent wells is presented in Sections 2 and 3.

Section 2

Field Methods

Subsurface drilling will be conducted using a sonic core drilling rig equipped with a continuous core barrel to facilitate detailed lithologic logging of aquifer materials, to collect depth-specific groundwater samples, and to install permanent monitoring wells. This method allows drilling to depths of more than 200 feet and uses only minimal volumes of drilling fluid (water).

2.1 Borehole Logging

Upon retrieval from the sonic core barrel, the soil and rock cores from the sonic boreholes will be logged as they are collected by the field geologist. At a minimum, this will include detailed visual examination in the field. Soil samples will be subjected to visual grain size examination and a description of other physical characteristics including color, sorting, etc. The grain size will be described in accordance with a system according to Burmister (1959). In addition, the Burmister classification will be converted to the Unified Soil Classification System (USCS) on the final boring log. Bedrock samples will be described as to lithology, mineralogy, degree and angle of fracturing, rock quality determination (RQD), etc.

Upon completion of drilling, a boring log will be prepared by the field geologist that contains specific details regarding the drilling or monitoring well procedure, a description of the encountered subsurface materials, information obtained from field readings (PID, etc.) and observations regarding evidence of contamination (i.e., discoloration, odor, etc.), and a drawing of record of any completed monitoring well.

Soil samples may be collected at certain locations in order to conduct a sieve analysis. Such samples will be placed in containers as soon after collection as practical. Core sample materials not reserved for later lithologic analysis will be placed back in the hole following borehole completion.

Bedrock is estimated to be at an elevation of 500' mean sea level (MSL) in the area of Grand River Dr. Terminal depth of each borehole will be reached when bedrock has been encountered. If a significant clay layer (5+ feet) is encountered, the drilling subcontractor will double case the boring to protect any potential confined aquifer (if present) until bedrock is reached. Once drilling has been completed, the field geologist will measure the total open depth of the borehole with a weighted, calibrated tape measure and document the depth followed by gamma-logging the complete borehole. Boreholes/well locations should be clearly designated in the field notebook using notes and a hand sketched layout and should include the following information:

- Measurements of each boring/sample point relative to fixed objects (building, structures, etc.).
- Boring/sample location with their identification number noted.
- North arrow or other compass directional indicator.

The amount of water added during drilling will also be recorded in the field notebook for use during vertical aquifer sampling. The procedures for the installation of the temporary well, the groundwater sampling, and the groundwater sample analysis are presented below.

2.2 Vertical Aquifer Sampling (VAS) and Analysis

Borehole groundwater samples will be obtained at discrete 5-foot intervals in order to perform VAS at the three-vertical profile soil boring locations along Grand River Drive, the one location east of MW-14R along 5-Mile Rd, and the one location between MD-7D and PT-1 (Figures 1 and 2). Drilling and VAS will be conducted using the Push-Ahead™ method due to its a bility to provide high quality samples that are generally unimpacted by the drilling operation and drilling fluids.

2.2.1 Push-Ahead™ Method

The Push-Ahead™ method has been developed by Boart Longyear/Cascade and is described in a paper by Cok, et al, 2008 titled "Push-Ahead™ Vertical Aqu ifer Sampling Method with Sonic Drilling", which is presented herein, as Appendix A.

> "The Push-Ahead™ sampler consists of a 2 7/8-inch I D drill rod threaded onto a carbide tipped drive point with flanges and sampling ports. The drive point sampling ports have a steel machined seal that remains closed until the tool is advanced to its desired sampling interval. Once the flanged drive tip is seated in the formation, the sampling ports are exposed by rotation of the drill rod. The sampling ports consist of four ¼-inch bor ings located at the base of the sampler drive head" (Cox, et al, 2008).

Discrete interval groundwater samples using the Push-Ahead™ sampler utilizes the advancement of a core barrel and outer casing(s) to the prescribed depth interval using the standard sonic drilling technolo gy. After the core barrel is removed (outer casing rema ins in place), a decontaminated and sealed Push-Ahead™ sampler is lowered to the bottom of the bori ng through the outer casing(s). The Push-Ahead™ sampler is then driven sonically below the bottom o f the boring into undisturbed soils (approximately 5 feet in advance of the outer casing depending on lithology) and beyond the zone of influence of the drilling operation. A decontaminated water level meter is us ed to verify that no water and/or drill fluids have entered the drill rods which verifies the seal of t he assembly. Upon verification of the seal, the Pus h-Ahead™ sampler is opened to allow formation water from the surrounding two feet of aquifer to enter the drill rods through the sampling ports. The entry ofgroundwater into the rods is verified with the water level meter. The water that has entered the sealed drill rods through the sampling port is considered to be representative of the formation water at the discre te interval of the port. Therefore, no purging of d rilling fluids is required prior to sample collection. A groundwater sample is then purged, stabilized, and collected from the drill rods with the use of a small-diamete r submersible pump as further described below in Section 2.2.2.

The primary advantage of the Push-Ahead™ sampler is its relative simplicity including no need for purging of drilling fluids prior to sample collection. Potential disadvantages of the Push-Ahead™ sampler include:

- A sample may not be collected within a reasonable period of time in a formation of low or moderate hydraulic conductivity and/or if the sample is not collected at a sufficient depth below the potentiometric surface.
- The sampler is blindly advanced beyond the drill stem and may not obtain a sample if seated in a lower hydraulic conductivity unit. If it is determined that a confining unit has been breached with this method, it can quickly be sealed off by advancement of the drill stem.

2.2.2 Groundwater Sampling

Once the Push-Ahead™ sampler is opened to allow for mation water to enter the drill rods through the sampling ports, a small-diameter submersible pump w ill be lowered into the drill rods and low-flow sampling techniques (Puls and Barcelona, 1996) will be used to collect a sample from the aquifer. As the water in the drill rods is being pumped, pH, temperature and specific conductance will be recorded every 3-5 minutes. The monitoring interval will be exten ded if the temporary well purges dry to allow time for the groundwater to recharge into the well. A groun dwater sample will be collected after the purge wat er stabilizes (defined as three successive readings where pH change is <10%, temperature change is <0.5°C and specific conductance change is <5%). After sta bility is achieved, the ammonia concentration will be measured colorimetrically in the field using field measurement kits manufactured by CHEMetrics. A groundwater sample will then be collected and analyzed for VOCs, PFAS, 1,4-dioxane, chromium VI, the MI 10-metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc – totals), dissolved potassium, dissolved magnesium, calcium, chloride, sulfate, total dissolved solids, dissolved sodium, and bicarbonate alkalinity as discussed below in subsection 2.2.3.

2.2.3 Groundwater Sample Analysis

Groundwater samples from each depth interval will be placed on ice, packaged, and sent to Test America Laboratory (TA) in Amherst, New York where they will be analyzed for VOCs, PFAS, 1,4-dioxane, chromium VI, the MI 10-metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc – totals), dissolved potassium, dissolved magnesium, calcium, chloride, sulfate, total dissolved solids, dissolved sodium, and bicarbonate alkalinity on a standard-turn basis. PFAS will be analyzed using EPA Method 537M while 1,4-dioxane will be analyzed using Method 8260 SIM.

Specific conductance, pH, temperature and ammonia concentrations will be measured in the field as described above in Section 2.1.2.

2.2.4 Quality Control Samples

Duplicate groundwater samples will be collected at a rate of approximately one duplicate for every 10 regular samples, in accordance with the Site's Groundwater Monitoring Plan (March 2007). In addition, two samples will be collected from the charge water (water) used to charge the casing during drilling to control sand heave. The origin of the charge water will be documented in the field notebook daily. The charge water samples will be analyzed for VOCs, PFAS, 1,4-dioxane, chromium VI, the MI 10-metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc – totals), dissolved potassium, dissolved magnesium, calcium, chloride, sulfate, total dissolved solids, dissolved sodium, and bicarbonate alkalinity. Three equipment rinse blanks will be collected during the field effort: a riser pipe blank, which is a water sample collected after soaking the galvanized steel in deionized/carbon filtered (DIC) water for approximately 10 minutes; a well screen blank, collected after soaking the temporary well screen in DIC water for approximately 10 minutes; and a pump blank, collected after running DIC water through the submersible pump. All three equipment rinse blanks will be analyzed for VOCs, PFAS, 1,4-dioxane, chromium VI, the MI 10-metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc – totals), dissolved potassium, dissolved magnesium, calcium, chloride, sulfate, total dissolved solids, dissolved sodium, and bicarbonate alkalinity on a standard-turn basis.

2.3 Decontamination Procedures and Investigation-Derived Waste (IDW)

After collecting a groundwater sample from one depth interval, the down-hole tubing used for that sample will be discarded and the pump will be cleaned thoroughly by placing the pump in a soapy water bath and running the pump for several minutes. Following the soap rinse, the pump will be placed in a DI water bath and run for several minutes. Fresh tubing will be used to collect each sample. At the completion of each boring, all augers and temporary well construction materials will be steam-cleaned before using those materials at a subsequent boring location.

The soil cuttings will be placed back into the bore hole once all the VAS sampling is completed. VOC and inorganic concentrations in the groundwater are very low, based on current and historical analytical results. Therefore, all well development water and groundwater sampling purge water will be containerized and transported to the State Disposal Landfill where it will be discharged into the main (front) sump.

2.4 Borehole Abandonment

Following the conclusion of groundwater VAS sampling in a borehole, the soil boring will be abandoned by simply pulling up the auger flights/casing and allo wing the formation to collapse. The bottom of any borehole where clay was penetrated more than 5 feet will be initially tremie grouted for two feet about the thickness of the amount of feet of clay drilled through followed then by pulling up the auger flights/casings and allowing the formation to collapse. Any remain ing space will be filled with soil cuttings and hyd rated bentonite chips to ground surface. Borehole abando nment forms will be included in the follow-up documentation report.

Section 3

Vertical Aquifer Screening Data Evaluation

During the VAS activities, groundwater samples will be collected at 5-foot intervals through the saturated thickness of the aquifer and analyzed for VOCs, PFAS, 1,4-dioxane, chromium VI, the MI 10-metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc – totals), dissolved potassium, dissolved magnesium, calcium, chloride, sulfate, total dissolved solids, dissolved sodium, ammonia and bicarbonate alkalinity.

After laboratory analysis of the samples is complete, the analytical results will be evaluated and a new permanent GSI monitoring well and screen interval will be selected and presented to the MDEQ. The following criteria will be used to select the GSI monitoring well location and screen depth interval:

- The interval of the highest VOC concentrations (if present), and to a lesser extent, the elevated specific conductance and ammonia concentrations.
- The interval of highest PFAS concentrations (if present), and to a lesser extent, the concentrations of calcium, chloride, sulfate, manganese, sodium and bicarbonate alkalinity compared to neighboring and selected site-wide monitoring wells.
- The interval corresponding to the screened interval of the existing neighboring GSI monitoring well.
- The interval corresponding with the most likely zone of historical or future impacts.

3.1 Potential Monitoring Well Installation and Development

Potentially three to five of the five vertical profile soil borings along Grand River Drive and in the area of 5 Mile may be turned into new permanent monitoring well and/or nested monitoring well locations. After the VAS laboratory data is received and evaluated along with historical ground water data from the area, the new permanent monitoring well and/or nested monitoring well locations and associated screened intervals will be selected and presented to MDEQ. The criteria that will be used to select which of the soil borings will be used for the new monitoring wells along with what the well screen depth interval will be at each of the selected locations is provided in Section 3. The potential monitoring well locations, screened interval, and nested monitoring well locations will not be determined until the VAS data has been reviewed (*ex.*, there is no need for a nested well or potentially any well at a location where VAS data shows non-detect).

The permanent monitoring wells will be installed by blind-drilling to approximately two feet below the bottom of the proposed screen interval with a Rotosonic. The wells will be constructed using 2-inch diameter Schedule 80 PVC pipe with 5-foot screens and 0.010-inch slots. The filter pack will extend from approximately two feet below the screen to two feet above the screen. An additional two to three feet of fine sand will be placed above the filter pack sand. The remaining annular space will be filled with bentonite/cement grout to one foot below ground surface. A protective casing with associated cement pad will then be installed over each of the new GSI monitoring wells.

The monitoring wells will be developed either by purging with a submersible pump (in wells where the depth to groundwater was less than 30 feet bgs) or by Grundfus pump (in wells where the depth to groundwater was more than 30 feet bgs). Turbidity and pH measurements will be collected periodically (generally after every 5-10 gallons of water has been removed) during well development and recorded in the field notebook. Wells will be developed until the turbidity of the purge water has decreased substantially, such that the purge water is mostly sediment free.

3.2 Ongoing Communications

With the recent news of PFAS investigations in Rockford and Belmont, WMMI reviewed public information regarding the Wolverine Worldwide site in Rockford as well as the NE Gravel site directly across the Grand River. The former NE Gravel Company is documented to have taken in tannery waste and plating material from numerous local companies and disposed of it all in unlined trenches. This former landfill is directly north of the of the Versluis wellfield, on the north side of the Grand River. Initial PFAS results currently show that while the Versluis wellfield is in use, groundwater may be pulled into the Plainfield Township wellfield from a higher concentration source via/under the Grand River from the North. All of this indicates there is likely a significant source across the Grand River from the Township's wellfield, a belief that was shown first on the 1996 State Disposal Landfill Remedial Investigation groundwater model flow map for the wellfield (Figure 4).

Section 4

Schedule

Proposed schedule:

1. Submittal of the Revised VAS and Monitoring Well Installation Work Plan (VAS MWIWP) February 14, 2018
2. MDEQ Review and Comment on the GSI MWIWP February 23, 2018[1]
3. VAS Activities (schedule to be confirmed with driller) March 12-23, 2018
4. Lab Turnaround Time (turnaround time to be confirmed with laboratory) April 9-20, 2018
5. WM Data Review and Design Basis April 30, 2018
6. MDEQ Design Basis Review and Comment May 7, 2018[1]
7. Monitoring Well Installation Field Implementation May 21-25, 2018

[1] These dates depend on the MDEQ's completion of their review processes and approval of the submitted Work Plan and subsequent Design Basis. Hence, all dates following these two tasks are estimated and subject to charge.

Section 5

References

Malcolm Pirnie, Inc. 1991. Phase I remedial investigation for Plainfield Township wells, Plainfield Township, Kent County, Michigan. August 1991.

Puls, R.W. and M.J. Barcelona. 1996. Low flow (minimal drawdown) groundwater sampling procedures. U.S. EPA Ground Water Iss., EPA/540/S-95/504.

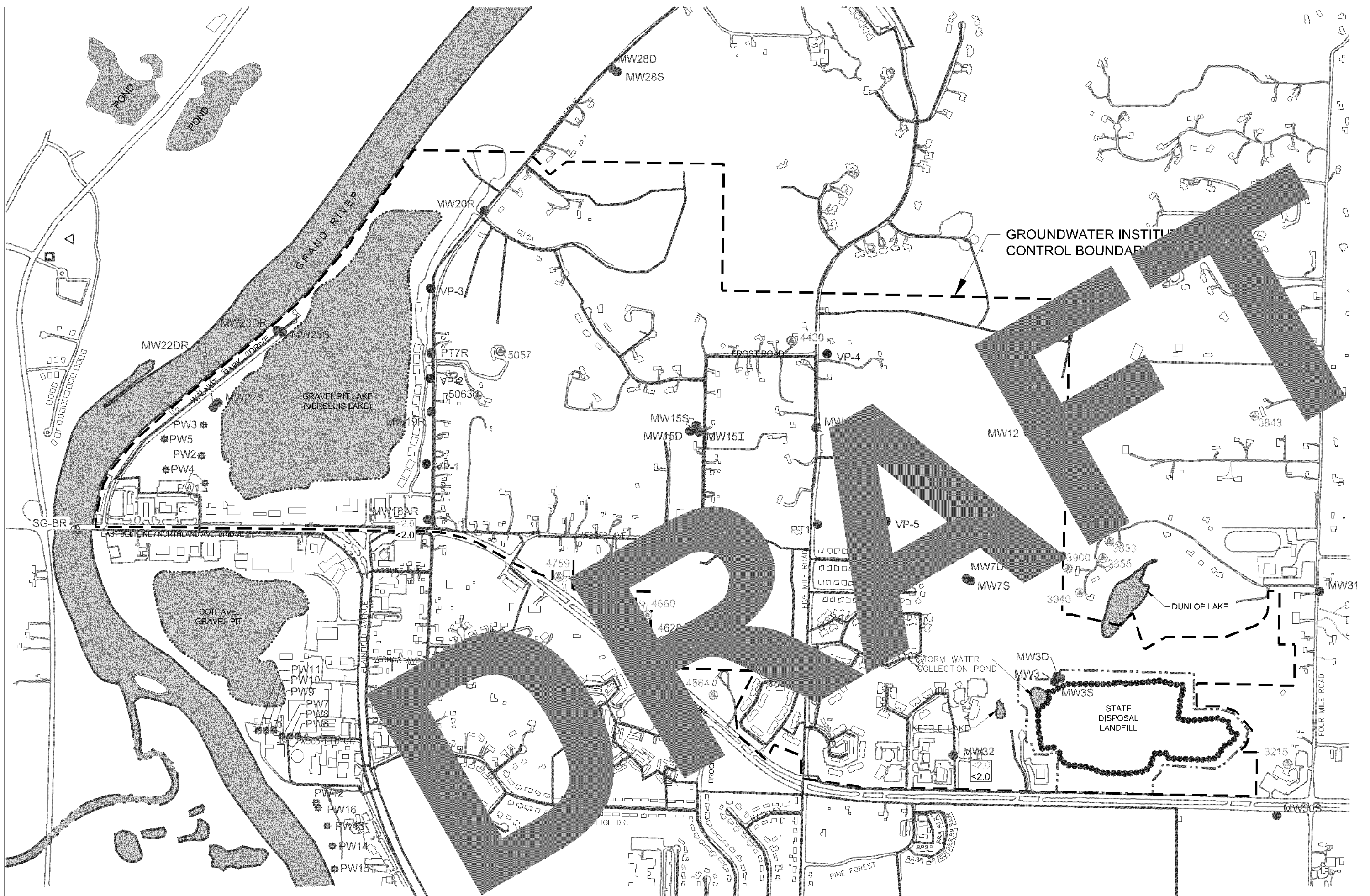
RMT, Inc. 2000. Remedial action plan for the State Disposal Landfill, Plainfield Township, Michigan. January 2000. (Not approved by the MDEQ).

RMT, Inc. 2006. Groundwater monitoring network upgrade, State Disposal Landfill, Plainfield Township, Michigan. May 2006.

RMT, Inc. 2007a. Groundwater monitoring plan - revision 1, State Disposal Landfill, Plainfield Township, Michigan. Original plan dated April 2006. Revision 1 dated March 2007.

RMT, Inc. 2007b. 2006 annual groundwater monitoring report, State Disposal Landfill, Plainfield Township, Michigan. March 2007.

Figures



LEGEND

	APPROXIMATE WASTE MANAGEMENT OF MICHIGAN, INC., PROPERTY LINE
	GROUNDWATER INSTITUTIONAL CONTROL BOUNDARY
	FOOTPRINT OF THE POST-COVER CONSTRUCTION STATE DISPOSAL LANDFILL
MW12	SAMPLED WATER TABLE WELL OR PIEZOMETER
MW12	WATER TABLE WELL OR PIEZOMETER MONITORED FOR WATER LEVELS ONLY
SG-BR	LOCATION ON BRIDGE WALKWAY USED FOR MEASURING RIVER STAGE
	PLAINFIELD TOWNSHIP WATER SUPPLY WELL
5057	PRIVATE WELL WITHIN THE GROUNDWATER INSTITUTIONAL CONTROL BOUNDARY (CURRENT AS OF JULY 2016). (SEE NOTE 4)
5057	RECENTLY CONFIRMED ABANDONED PRIVATE WELL (SEE NOTE 4)
3940	PRIVATE WELL OUTSIDE THE GROUNDWATER INSTITUTIONAL CONTROL BOUNDARY (CURRENT AS OF OCT 2016). THESES WELLS HAVE BEEN OR HAVE BEEN OFFERED TO BE SAMPLED FOR PFAS ANALYSIS.
	EXISTING WATER MAIN
VP-2	VERTICAL AQUIFER PROFILE BORING
	ACTIVE GRAVEL PIT
	ESTIMATED GRAND RAPIDS GRAVEL IRRIGATION WELL LOCATION

WELL DESIGNATION KEY

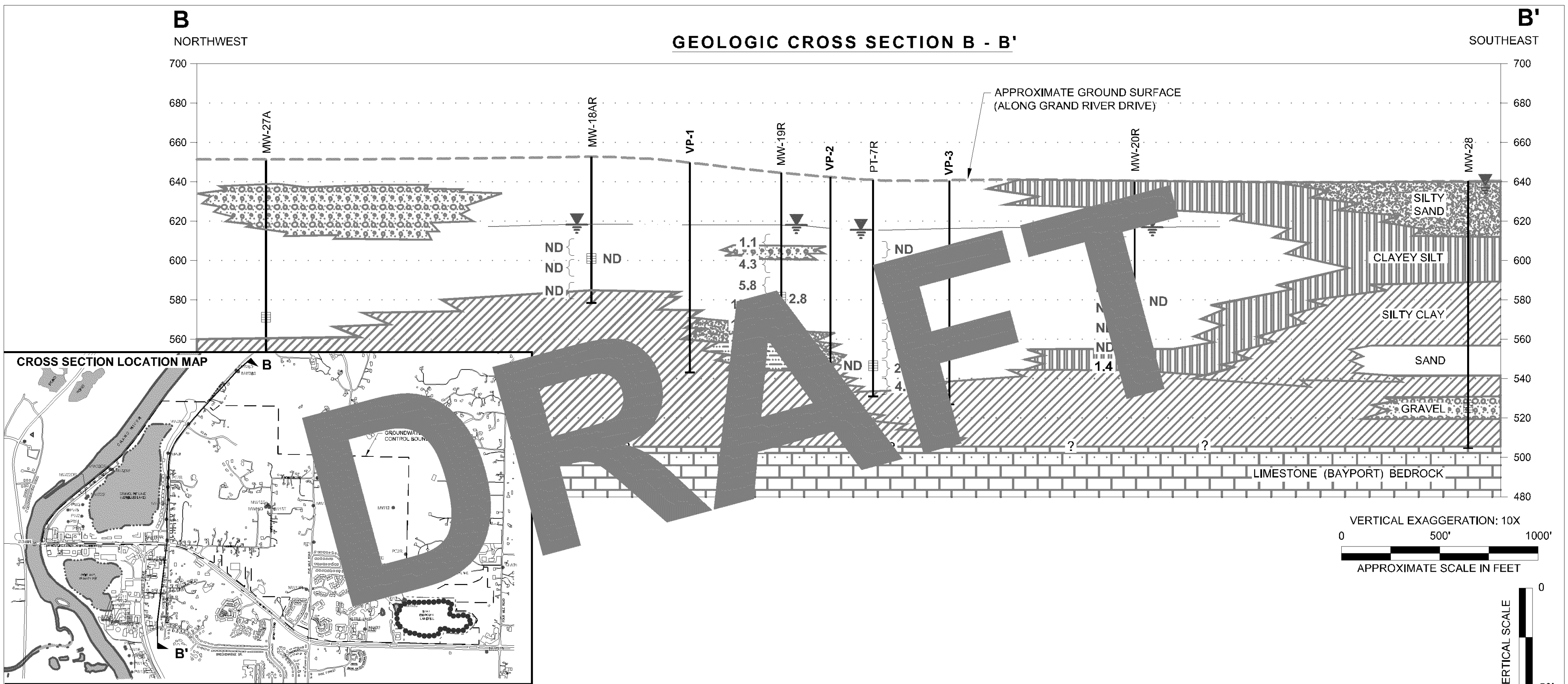
MW1	WASTE MANAGEMENT OF MICHIGAN MONITORING WELL
PZ1	WASTE MANAGEMENT OF MICHIGAN MONITORING WELL (ORIGINALLY INSTALLED BY THE MDEQ)
PT1	PLAINFIELD TOWNSHIP MONITORING WELL
PW	PLAINFIELD TOWNSHIP WATER SUPPLY WELL

0 1200' 2400'
SCALE IN FEET

NOTES

1. ONLY THOSE MONITORING WELLS THAT ARE INCLUDED IN THE POST-CLOSURE GROUNDWATER MONITORING PROGRAM ARE SHOWN ON THIS FIGURE.
2. BASE MAP DEVELOPED FROM AERIAL PHOTOGRAPH TAKEN IN APRIL 2003, AS PROVIDED BY REGIS.
3. ON JULY 19, 2016 WASTE MANAGEMENT MET WITH THE KENT COUNTY HEALTH DEPARTMENT (KCHD) WHO CONFIRMED NO NEW WELLS HAVE BEEN INSTALLED WITHIN THE GROUNDWATER INSTITUTIONAL CONTROL BOUNDARY SINCE THE JANUARY 2000 WELL SURVEY.
4. 3612 HORDYK ST AND 4430 FROST RD: CONFIRMED TO BE ABANDONED BY FIELD VERIFICATION ON AUG 5, 2016 AND CONFIRMED TO HAVE WATER METERS BY THE PLAINFIELD TOWNSHIP WATER DEPT (PTWD) ON MARCH 6, 2017. 5057 GRAND RIVER DR: CONFIRMED TO BE ABANDONED IN 2006. CONFIRMED TO HAVE A WATER METER BY PTWD ON MARCH 6, 2017. 5063 GRAND RIVER DR: CONFIRMED TO BE USED FOR IRRIGATION PURPOSES ONLY IN 2006. UPDATED WELL USE INFORMATION WAS NOT ABLE TO BE OBTAINED IN AUG 2016 OR MARCH 2017. CONFIRMED TO HAVE A WATER METER BY PTWD ON MARCH 6, 2017. 4759 E. BELTLINE: CONFIRMED TO EXIST BY PTWD ON MARCH 6, 2017. PARCEL IS OUTSIDE THE GROUNDWATER INSTITUTIONAL CONTROL BOUNDARY (GWICB) BECAUSE NO IMPACT BY THE LANDFILL FOUND IN NEARBY MONITORING WELL MW-18AR OR FORMER MONITORING WELLS WEST OF THE E. BELTLINE. 4660 E. BELTLINE: CONFIRMED TO EXIST BY PTWD ON MARCH 6, 2017. MONITORED BY THE KENT COUNTY HEALTH DEPT (KCHD) DUE TO A LUST ON THE NEIGHBORING PROPERTY. HISTORICAL SAMPLING BY WM SHOWED NO LANDFILL IMPACT. 4628 E. BELTLINE: CONFIRMED TO EXIST BY PTWD ON MARCH 6, 2017. MONITORED BY THE KENT COUNTY HEALTH DEPT (KCHD) DUE TO AN ON-SITE LUST. HISTORICAL SAMPLING BY WM SHOWED NO LANDFILL IMPACT. DUE TO THE LARGE SIZE OF THE PARCEL (E. BELTLINE TO WEBBER AVE), IT REMAINS INSIDE THE GWICB (I.E., EASTERN EDGE OF PARCEL CLOSE TO LANDFILL IMPACTED AREA). 4564 E. BELTLINE: CONFIRMED TO EXIST BY PTWD ON MARCH 6, 2017. PARCEL IS OUTSIDE THE GWICB BECAUSE NO IMPACT BY THE LANDFILL FOUND IN NEARBY MONITORING WELL MW-13R OR FORMER MONITORING WELLS WEST OF THE E. BELTLINE. 3940 DUNLOP LAKE LN: CONFIRMED TO EXIST IN AUG 2016 AND CONFIRMED TO BE OUTSIDE THE GWICB WHEN THE AREA'S PARCEL LINES WERE UPDATED IN NOV 2016. 3215 4 MILE: CONFIRMED TO EXIST IN AUG 2016, HOWEVER IS UPGRADIENT OF THE LANDFILL AND THEREFORE IS OUTSIDE OF THE GWICB.

Brown AND Caldwell	SCALE: 1" = 1200' 148916 DATE: JANUARY 2018	STATE DISPOSAL LANDFILL SITE LAYOUT PLAINFIELD TOWNSHIP, MICHIGAN	FIGURE 1



LEGEND

- APPROXIMATE GROUND SURFACE
- STRATIGRAPHIC CONTACT (DASHED WHERE INFERRED)
- GROUNDWATER ELEVATION (JUNE 2010) AND APPROXIMATE WATER TABLE
- VP-1 — PROPOSED LOCATION AND APPROXIMATE DEPTH OF VERTICAL AQUIFER SAMPLING LOCATION

MONITORING WELL (TYPICAL)

- TOP OF CASING
- MONITORING WELL SCREEN
- END OF BORING
- 1.1 / ND — VERTICAL SAMPLING INTERVAL AND RESULTS FOR TOTAL VOCs IN ug/L (ND = NOT DETECTED)
- ND — WELL SCREEN INTERVAL WITH TOTAL VOC RESULT (OCTOBER 2017)

- SAND
- GRAVEL
- SILTY SAND
- CLAYEY SILT
- SILTY CLAY
- SANDSTONE BOULDER
- LIMESTONE BEDROCK

NOTES

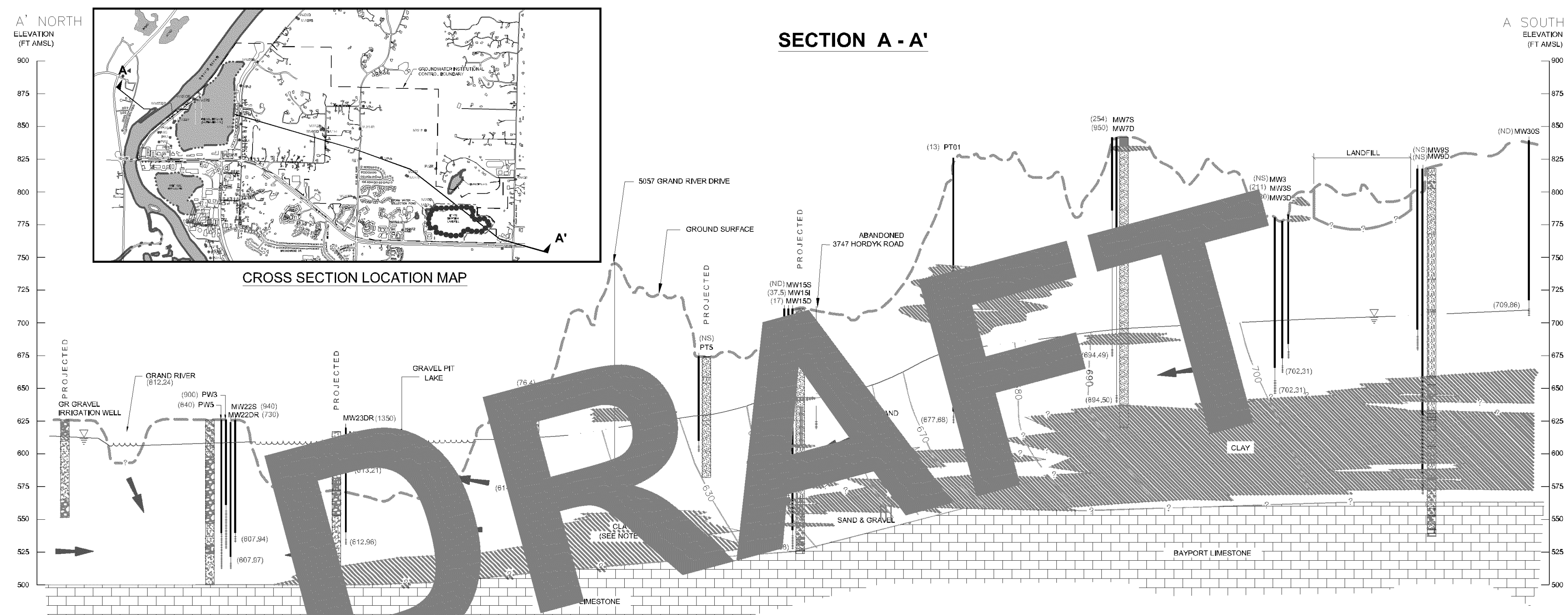
1. VERTICAL PROFILE DATA COLLECTED IN 2006 AND 2007; WELL DATA FROM OCTOBER 2017 MONITORING EVENT.
2. VOC DETECTION AT WATER TABLE IN MW-20R WAS ALL ACETONE, WHICH IS NOT A CONSTITUENT OF CONCERN, AND IS BELIEVED TO BE A FALSE POSITIVE.
3. VOC DETECTION AT BOTTOM OF MW-20R BORING WAS CHLOROFORM. INDICATING THAT NOT ALL OF THE MUNICIPAL WATER USED IN DRILLING HAD BEEN PURGED FROM WELL BEFORE SAMPLING.
4. WATER LEVEL IN MW-28 AND LOGGED GEOLOGY INDICATE WELL IS SCREENED IN ARTESIAN AQUIFER.
5. SUBSURFACE GEOLOGY BASED IN PART ON A SANDSTONE ENCOUNTERED AT THE BOTTOM OF THE MW-19 BORING. ONE INTERPRETATION ASSUMES THAT THE SANDSTONE REPRESENTS BEDROCK OF THE SAGINAW FORMATION, WHICH ACCORDING TO THE LITERATURE CONSISTS OF ALTERNATING LAYERS OF SANDSTONE, SHALY LIMESTONE, AND SHALE. ANALYSIS OF A DEEP OIL AND GAS WELL LOG LOCATED TEN MILES TO THE NORTH OF THIS LOCATION SHOWS THAT SAGINAW FORMATION COULD BE PRESENT HERE. HOWEVER, BECAUSE A BASAL CLAY TILL HAS BEEN ENCOUNTERED IN ALL THE OTHER BORINGS SHOWN ON THIS CROSS SECTION, IT IS JUST AS LIKELY THAT THE SANDSTONE ENCOUNTERED WAS A LARGE GLACIAL ERRATIC (BOULDER) BECAUSE NO BASAL GLACIAL TILL WAS ENCOUNTERED ABOVE IT.

Brown AND Caldwell

SCALE: AS SHOWN
148916
DATE: JANUARY 2018

STATE DISPOSAL LANDFILL
GRAND RIVER DR. VERTICAL AQUIFER SAMPLING LOCATIONS IN GEOLOGICAL CROSS SECTION
PLAINFIELD TOWNSHIP, MICHIGAN

FIGURE 2

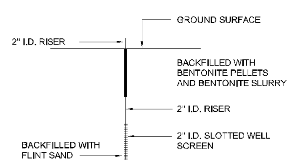


NOTES

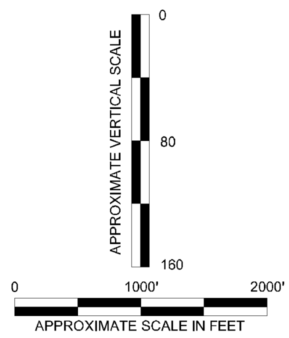
1. FIGURE ADAPTED FROM ORIGINAL CROSS SECTION FROM MONTGOMERY WATSON (1996).
2. THE STRATUM LINES ARE BASED ON INTERPOLATION BETWEEN BORINGS AND MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. QUESTION MARKS AT THE CONTACTS BETWEEN SUBSOIL TYPES INDICATE THE CONTACTS ARE INFERRED.
3. AMSL INDICATES ABOVE MEAN SEA LEVEL.
4. HORIZONTAL DISTANCES ARE MEASURED WITH RESPECT TO THE CENTER OF EACH SOIL BORING LOCATION.
5. ELEVATIONS OF LAND SURFACES ARE APPROXIMATE AND ARE BASED ON TOPOGRAPHIC MAP PROVIDED BY WASTE MANAGEMENT OF NORTH AMERICA, DATED APRIL 27, 1990.
6. GROUNDWATER ELEVATIONS ARE BASED ON MEASUREMENTS OBTAINED BY BROWN AND CALDWELL ON APRIL 24 & 25(MW-22S, -22DR, -23DR), 2017.
7. POTENTIOMETRIC CONTOUR INTERVAL IS 10 FEET. THE POTENTIOMETRIC LINE IS DASHED WHERE INFERRED.
8. THE BORINGS AND MONITORING WELLS AT MW15(S/I/D), PT5 AND MW23 (S/DR) ARE PROJECTED FROM ANOTHER LOCATION ALONG THE GRAVEL PIT LAKE SHORELINE.
9. CONCENTRATIONS SHOWN ARE THE SUM OF DETECTABLE PERFLUOROOCTANIC ACID(PFOA) AND PERFLUOROOCTANE SULFONIC ACID(PFOS) IN GROUNDWATER SAMPLES ANALYZED USING EPA METHOD 537.
10. ND = NOT DETECTED.
11. NS = NOT SAMPLED.

LEGEND

- WATER TABLE
- (702.16) WATER LEVEL ELEVATIONS (FT AMSL)
- (8.7) TOTAL PFOA & PFOS CONCENTRATION (mg/L)
- POTENTIOMETRIC CONTOUR (FT AMSL)
- GROUNDWATER FLOW DIRECTION
- LEAN CLAY
- SANDY LEAN CLAY
- SILTY CLAY
- WELL-GRADED / POORLY-GRADED SAND
- WELL-GRADED / POORLY-GRADED SAND, WITH GRAVEL
- SILTY SAND
- LIMESTONE
- CLAYEY SAND
- SILT
- SANDY SILT
- GRAVELLY SILT
- WELL-GRADED / POORLY-GRADED GRAVEL
- WELL-GRADED / POORLY-GRADED GRAVEL WITH SAND
- SILTY GRAVEL



TYPICAL WELL INSTALLATION DETAIL



VERTICAL EXAGGERATION: 12.5X

Brown AND Caldwell

SCALE: AS SHOWN

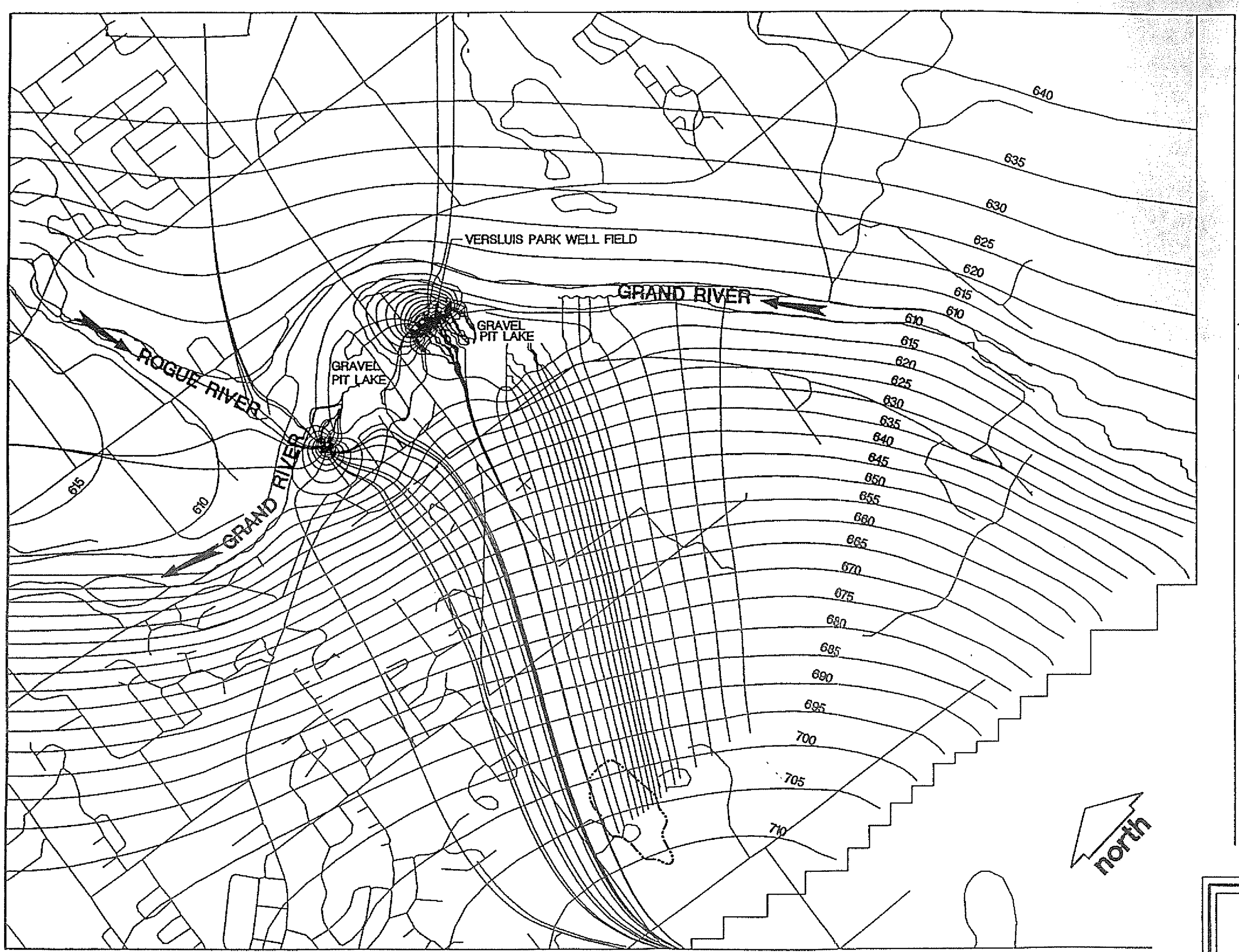
148916

DATE: JANUARY 2018

STATE DISPOSAL LANDFILL
GROUNDWATER EQUIPOTENTIAL AND TOTAL PFOA & PFOS
CONCENTRATIONS IN CROSS SECTION
PLAINFIELD TOWNSHIP, MICHIGAN

FIGURE
3

Path: C:\WasteManagement\State Disposal LF\CAD-ES\Figures\PFC Sampling File Name: SECTIONS_FIG-3 Plot Date: January 16, 2018 1:00 PM Cadd User: Andrew Hutt



LEGEND

- SURFACE WATER FLOW DIRECTION
- GROUNDWATER FLOW LINES (PATH LINES)
- 710 GROUNDWATER CONTOUR LINES AND ELEVATION
- APPROXIMATE EXTENT OF FILL

NOTES

1. BASE MAP DEVELOPED FROM THE ROCKFORD, MICHIGAN 7.5 MINUTE U.S.G.S. TOPOGRAPHIC QUADRANGLE MAP, DATED 1967, PHOTOREVISED 1981.

0 2000 4000
SCALE IN FEET

GROUNDWATER REMEDIAL INVESTIGATION REPORT
STATE DISPOSAL LANDFILL
PLAINFIELD TOWNSHIP, MICHIGAN

MAXIMUM PRODUCTION RATE SIMULATION - CAPTURE ZONE MAP

FIGURE 3-5

MONTGOMERY WATSON

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FIGURE 4

Appendix A: Push-Ahead™ Method

Push-Ahead™ Vertical Aquifer Sampling Methodology with Sonic Drilling

Abstract

Ground water investigations of dense non-aqueous phase liquid (DNAPL) or brine plumes that extend hundreds of feet deep into unconsolidated sediments present drilling and sampling challenges that can greatly increase investigation time and cost. Sonic drilling methodology is a preferred sampling method in these environments for its superior drilling speed, good recovery of undisturbed, large-diameter core samples, significant reduction of derived waste, uniform boreholes with a minimum of drift and the ability to seal off saturated zones from one another without setting permanent multiple outer-well casings. However, the required inducement of fluids during drill stem advancement can greatly increase time and expense where the collection of vertical aquifer profile (VAP) sampling is desired. PROSONIC Corporation (recently purchased by Boart Longyear Inc., hereafter Boart) has developed a new Push-Ahead™ sampling device that can collect representative ground water VAP samples while minimizing purge volumes and sampling time.

The sonic drilling Push-Ahead™ sampler was developed to overcome sampling difficulties at a State of Michigan Department of Environmental Quality (MDEQ) Site investigation of a 7-mile long TCE plume located in the vicinity of Mancelona, Michigan. From 2004 through 2006, the State retained Boart to advance 26 VAP borings and install 32 monitoring wells. Glacial alluvial sediments were explored to depths approaching 600 feet below ground level. Use of the Push-Ahead™ VAP sampling device resulted in significantly reduced purge water volumes and sampling time. Comparison of data and quality objectives are assessed using the new sonic drilling Push-Ahead™ sampler for VAP sampling method from those employed using traditional sonic drilling VAP sampling techniques.

Introduction

Ground water investigations of DNAPL or brine plumes that extend hundreds deep feet into unconsolidated drinking water aquifers can be extremely costly and time consuming to adequately investigate as required by State and Federal regulations. The drilling and sampling challenges to investigating ground water quality at these depths are beyond the capabilities of most drilling methodologies.

Sonic drilling methodology is a preferred drilling and sampling technique for deep ground water investigations. Due to it's superior drilling speed; good recovery of undisturbed, large diameter core samples; significant reduction of derived waste; uniform boreholes with a

PRESENTED BY:

Thomas Cok, CPG
The Mannik & Smith Group, Inc.

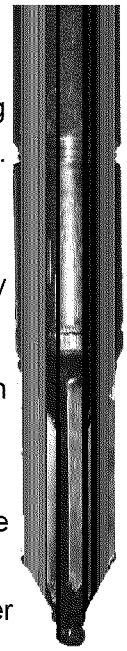
Dennis Robins
Boart Longyear

Mark Schult, Ph.D.
The Mannik & Smith Group, Inc.

Walter Bolt, CPG
The Mannik & Smith Group, Inc.

minimum of drift; and the ability to seal off saturated zones from one another without setting multiple permanent outer well casings. Sonic drilling method can extend borings in unconsolidated sediments to depths in excess of 700 feet. However, the advancement of the drill stem (multiple outer casings and core barrel) into the unconsolidated sediments, particularly angular sands, typically requires the inducement of drilling fluids. The quantity of water required to advance the casing generally increases with depth to due to increased friction against the casing. VAP sampling is generally conducted during drill stem advancement to assure proper selection of the monitoring well screened interval. The inducement of fluids during drill stem advancement can greatly increase the time and expense to collect representative VAP samples from the aquifer.

Traditional methods of VAP sampling with sonic drilling involve the installation of temporary wells within the drill stem and then retracting the drill stem to expose the screen. This leaves the temporary well casing filled with drill fluids and its screened interval in the zone of influence of the induced drilling fluids. Extensive purging of the temporary well is required to collect a representative formation sample. Other limited push ahead techniques have been developed (i.e. Simulprobe® or Hydropunch™), however, these limited push ahead techniques will generally not allow advancement more than a few feet beyond the drill stem and are still in the zone of influence of the induced drill fluids. Additionally these limited drive ahead techniques have minimal, if any, purge capabilities.



Original
Push-Ahead

Boart has developed a new push ahead sampling device for use with the sonic drilling technique that can collect representative samples while eliminating purging requirements and minimizing sampling time. The Push-Ahead™ sampler is advanced without inducing additional drilling fluids and extends beyond the zone of influence of the drilling fluids that has been induced into the formation. Upon opening the sampling ports, an unadulterated representative VAP sample is collected directly from the zone of interest without purging requirements. If purging is desired, a sampling pump with or without a packer can be inserted into the drill rod to obtain the sample. The drill rod with the Push-Ahead™ sampler can then be removed and decontaminated for it next use.

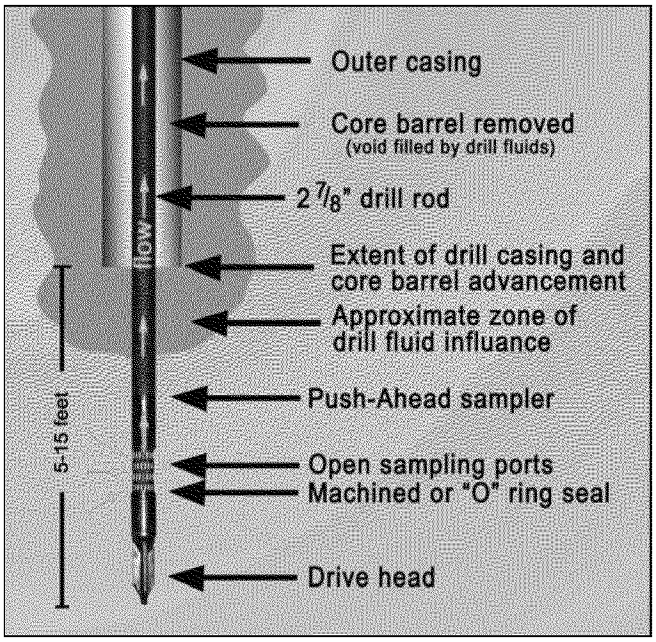
To date, the Push-Ahead™ sampler has been approved and satisfactorily utilized at two MDEQ site investigations. The Wickes Manufacturing site investigation in Mancelona, Michigan conducted VAP sampling of a TCE plume with the sonic drilling Push-Ahead™ sampler to depths approaching 600 feet below ground surface (bgs). The Hoskins Manufacturing site in Mio, Michigan investigated a chlorinated solvent plume and hexavalent chromium release associated with a brine plume through multiple aquifers to depths over 400 bgs.

MDEQ has also approved use of the Push-Ahead™ sampler at the MDEQ Rexair site in Cadillac, Michigan to conduct VAP sampling of a chlorinated solvent plume through multiple aquifers to depths of approximately 330 bgs. At the Rexair project, the MDEQ contractor, the Mannik and Smith Group (MSG), will utilize the next generation (TNG) Push-Ahead™ sampler. The TNG Push-Ahead™ sampler has an improved sampling port seal, increase sampling port capacity, and a finer sampling port opening size to minimize sediment intake (See TNG Push-Ahead™ sampler Figure, next page).

This study examines the Push-Ahead™ sampler and its use, using the Wickes Manufacturing site as a case study where both the Push-Ahead™ sampler and standard temporary well technique were utilized to conduct VAP sampling. The case study is assessed for VAP sampling cost and time savings provided by use of the Push-Ahead™ sampler in comparison to traditional temporary monitor well methodology.

Push-Ahead™ Sampler Description and Methodology

The Push-Ahead™ sampler consists of a 2 7/8-inch ID drill rod threaded onto a carbide tipped drive point with flanges and sampling ports. The drive point sampling ports have a steel machined seal that remains closed until the tool is advanced to it desired sampling interval. Once the flanged drive tip is seated in the formation, the sampling ports are exposed by rotation of the drill rod. The sampling ports consist of four ¼-inch borings located at the base of the sampler drive head (See Original Push-Ahead™ sampler, previous page.)



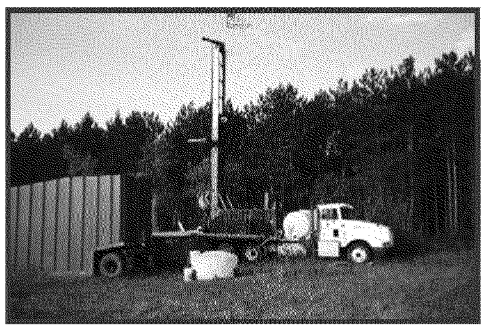
Next generation Push-Ahead Sampler

The VAP sampling methodology utilizing the sonic drilling Push-Ahead™ sampler involves the advancement of core barrel and outer casing(s) to the water table or chosen depth interval using standard sonic drilling technologies. After the removal of the core barrel, a decontaminated and sealed Push-Ahead™ sampler is inserted through the outer casing(s) to the bottom of the boring. The Push-Ahead™ sampler is the sonically driven beyond the boring bottom into virgin material (approximately 5 to 15 feet in advance of the outer casing depending on lithology) beyond the zone of influence from any induced drill fluids (**See Push-Ahead™ Sample Collection Illustration, left**). A water level meter is then lowered within the drill rods to verify the seal and ensure no drill fluids has entered the drive point assembly. Once the seal is verified, the water level meter is removed and the Push-Ahead™ sampler is opened to allow formation water to enter the drill rods through the sampling ports. The water level meter is then re-lowered into the drill rods to verify formation water has entered the drill string. Since the ground water entering the drill rod through the sampling ports is representative of the formation (collected from beyond the zone of drill fluids influence), no purging is required but may be conducted if desired to reduce turbidly. Samples are collected directly from the drill rod using a bailer or submersible pump.

Draw backs to the use of the Push-Ahead™ sampler are 1) it is blindly advanced beyond the drill stem and may not obtain a sample if seated in a low permeability soil and 2) the sampler could potentially penetrate a confining layer. If a confining unit is breached, it can quickly be sealed off by advancement of the drill stem.

Case Study

The MDEQ retained Boart to conduct a Supplemental Investigation/ Monitoring Well Installation Project for the Wickes Manufacturing TCE Plume site in Mancelona, Michigan (Site). Boart retained the MSG as a subcontractor to aid them.



The former Wickes Manufacturing has operated as a manufacturing facility under various owners since the 1950's. Scrap steel saturated with chlorinated paraffins was stockpiled outside the plant and untreated wastewater was discharged to three seepage pits. TCE concentrations in ground water have been detected at levels exceeding 1,000 parts per billion. Prior investigations identified a TCE ground water plume extending approximately seven miles northwest from the former Wickes Manufacturing property.

The site lies on glacial outwash sand and gravel with post-glacial alluvium. Thickness of the unconsolidated sediments is reported to range from between 200 and 600 feet at the site. A regional aquifer exists within the unconsolidated soils and is present as inter-bedded aquifers, aquitards and aquicludes in the site vicinity. Regional ground water flow is to the northwest. Ground water is encountered at the site at depths ranging from less than 20 feet up to 260 feet below grade. From 2004 through 2006, Boart advanced 26 VAP borings and installed 32 monitoring wells. A total of 326 VAP samples were collected from the borings. Glacial alluvial sediments were explored to depths approaching 600 feet bgs.

Due to the extensive boring depths and angularity of the sands, large quantities of drilling fluids (treated city water) were required to advance the drill stem. Typically advancement of a 20 foot run of the override casing during sonic drilling requires inducing 50 to 100 gallons of drilling fluids into the formation, deeper runs requiring up to 1000 gallons.

In October 2004, the initial 15 VAP borings were completed and 188 VAP samples were collected using temporary monitoring wells to collect representative water samples. Based on the monitoring for the presences of products associated with the use of city water (trihalomethanes) and the stabilization of field monitoring parameters during purging (temperature, pH, conductivity, and turbidly), approximately 1.5 times the volume of induced drill fluids had to be purged to collect a representative sample. Approximately 120,000 gallons of purge water was generated and required off-site disposal as a result of the temporary well VAP sampling methodology.

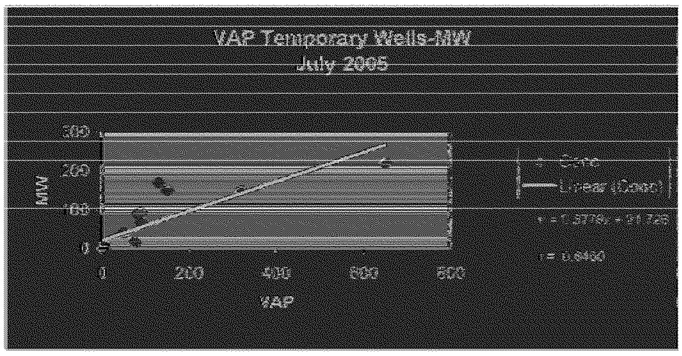
In 2005, Boart developed the Push-Ahead™ sampler as a means to eliminate purging requirements and significantly reduce sampling time for the second phase of drilling. During the second phase of drilling, 13 VAP borings were completed and 138 VAP samples were collected, of which 129 samples were collected using the Push-Ahead™ sampler.

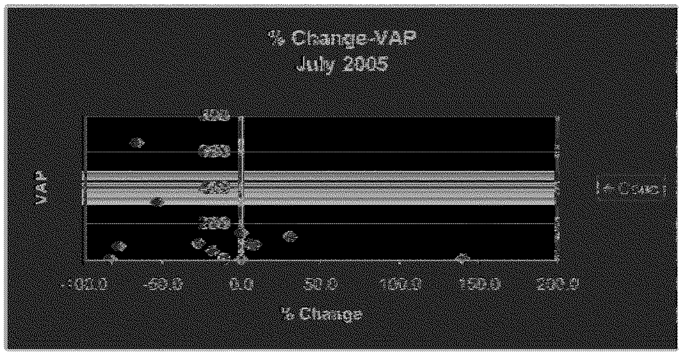
Statistical Comparison of Sampling Data

The data set consists of sample results from the VAP samples, sampling time, and purge water quantities during both phases, and the first following monitoring well sampling event. The VAP sample from the interval closest to the monitoring well screened interval was used for the comparisons. The VAP concentrations were plotted against the corresponding monitoring well concentrations from the monitoring well sampling event immediately after well installation (i.e., the July 2005 data from VAP borings installed in 2004 and the November 2006 data for VAP borings installed in 2005-2006). Linear regressions were then performed on the TCE concentration results from the traditional temporary monitoring well VAP sample collection data and the Push-Ahead™ sampler VAP data.

As part of the analysis, the Pearson's coefficient (also known as the correlation coefficient) was calculated for each data set. The Pearson's coefficient is a measure of the strength of the linear relationship between two variables. Pearson's coefficient values range from +1 to -1, with +1 indicating a direct relationship and -1 indicating an inverse relationship. The Pearson's coefficients were compared to $r_{.005}$ (the critical value for statistical significance), which indicates the correlation is significant at the 99.5 percent level (or that there is a 0.5 percent chance that the correlation appears to be true but is not).

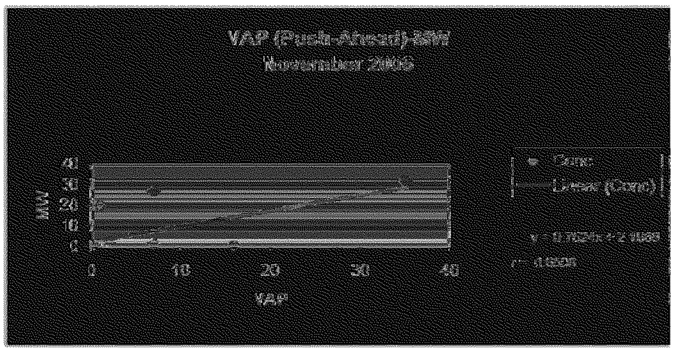
The temporary well VAP data shows a statistically significant linear relationship with the subsequent monitoring well sampling event (See VAP Temporary Wells – MW July 2005 Figure, below), with a Pearson's coefficient of 0.846 and a $r_{.005}$ value of 0.590. Most temporary well VAP sample results were higher than the corresponding monitoring well's results.

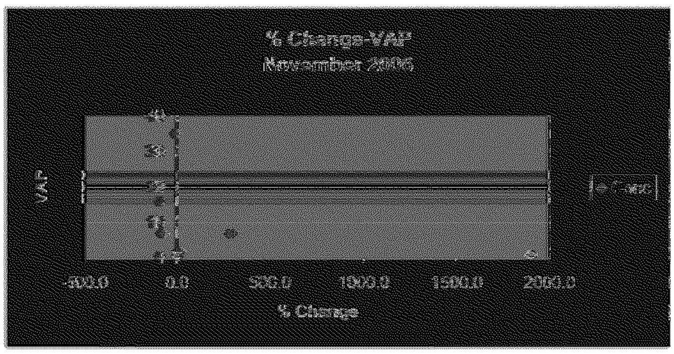




The Push-Ahead™ sampler VAP data shows a statistically significant linear relationship with the subsequent monitoring well sampling event (See VAP Push-Ahead – MW November 2006 Figure). However, the Pearson's coefficient is 0.651, slightly above the $r_{.005}$ value of 0.641. The Push-Ahead™ sampler VAP results were quite variable compared to the corresponding monitoring well's results. One major factor for the lower Pearson's coefficient and the variability may be that the Push-Ahead™ VAP locations and monitoring wells were near the edge of the plume and thus lower overall chemical concentrations were obtained. Additionally, monitoring wells installed at the plumes edge may be more prone to temporal variation as the plume expands or due to minor seasonal variations in ground water flow direction. As a result, a difference of a few micrograms per liter would cause more scatter of the data and a much larger percentage change than the data from locations with higher concentrations, where a small absolute difference between the temporary well and monitoring well data would not influence the correlation as much.

Both the temporary wells and Push-Ahead™ sampler data show a statistically significant linear trend when compared to the monitoring well data. The different strengths of correlation is likely due to sample locations and not sampling methodology as additional data collected from future investigation are obtain with the Push-Ahead™ sampler, including VAP sampling through highly concentrated portions of the plumes, this data should be statistically evaluated to asses the technique correlation with traditional VAP sampling methods.





Time and Purge Water Disposal Cost Savings

During the 2004 VAP sampling, 188 VAP samples were collected using temporary wells in approximately 120 days of fieldwork (typically 10 hour work days).

The average boring length during this sampling event was 371 feet. The average collection rate was approximately 1.6 samples per day.

During the 2005-2006 VAP sampling, 128 samples were collected in 69 days of fieldwork. Temporary well VAP sampling was conducted in one boring to a depth of 457 feet. A total of 13 samples were collected in 9 days from this boring, for an average collection rate of 1.4 samples per day. Twelve VAP borings were sampled utilizing the Push-Ahead™ sampler device to an average depth of 419 feet. A total 129 Push-Ahead™ VAP samples were collected in 60 days, for an average collection rate of 2.2 samples per day.

Comparisons of the VAP sample collection rates from temporary wells and Push-Ahead™ technique indicates a field time saving of approximately 30 percent. Utilization of the Push Ahead™ technique during the 2004 VAP boring would likely have reduce the field duration by 40 out of the 120 days and cost savings at standard sonic drill crew rates in excess of $240,000. Purging of the temporary wells prior to sampling generated approximately 120,000-gallons (on average 638 gallons per sample) impacted water requiring off-site disposal. At $0.25 per gallon for non-hazardous disposal, this volume would cost $30,000 for disposal.

Conclusions

The Push-Ahead™ sampler was developed to overcome sampling difficulties associated with induced drilling fluids. Use of the Push-Ahead™ sampler resulted in the elimination of purge water and greatly reduced VAP sampling time and cost. Comparison of data and quality objectives using the new Push-Ahead™ sampler device to traditional sonic drilling VAP sampling techniques found both methods provide statistically correlated data to formation conditions (permanent monitoring well results). In the case study, the degree of correlation to permanent monitoring well results was slightly better with the traditional VAP sampling, however this may be due to the selected Push-Ahead™ sampler boring locations at the plume edges.

Acknowledgements

We greatly acknowledge the cooperation and information provided by Boart Longyear in the development and use of the Push-Ahead™ VAP sampler. The authors also wish to thank the Michigan Department of Environmental Quality (MDEQ) and their Level of Effort project contractor, Mactec Engineering and Consulting of Michigan for providing the analytical data evaluated in this study.